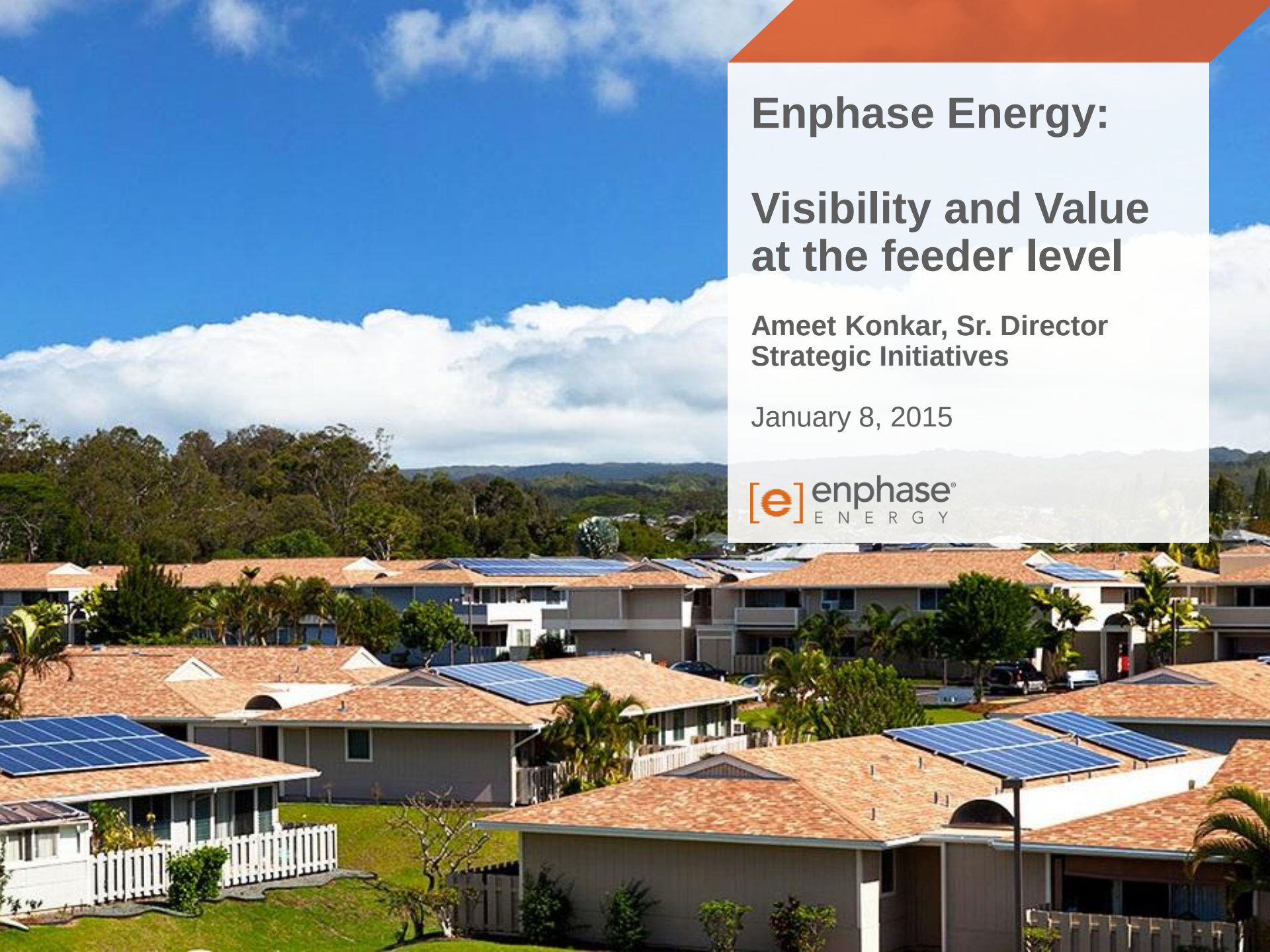

Enphase Energy:

Visibility and Value at the feeder level

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Strategic Initiatives

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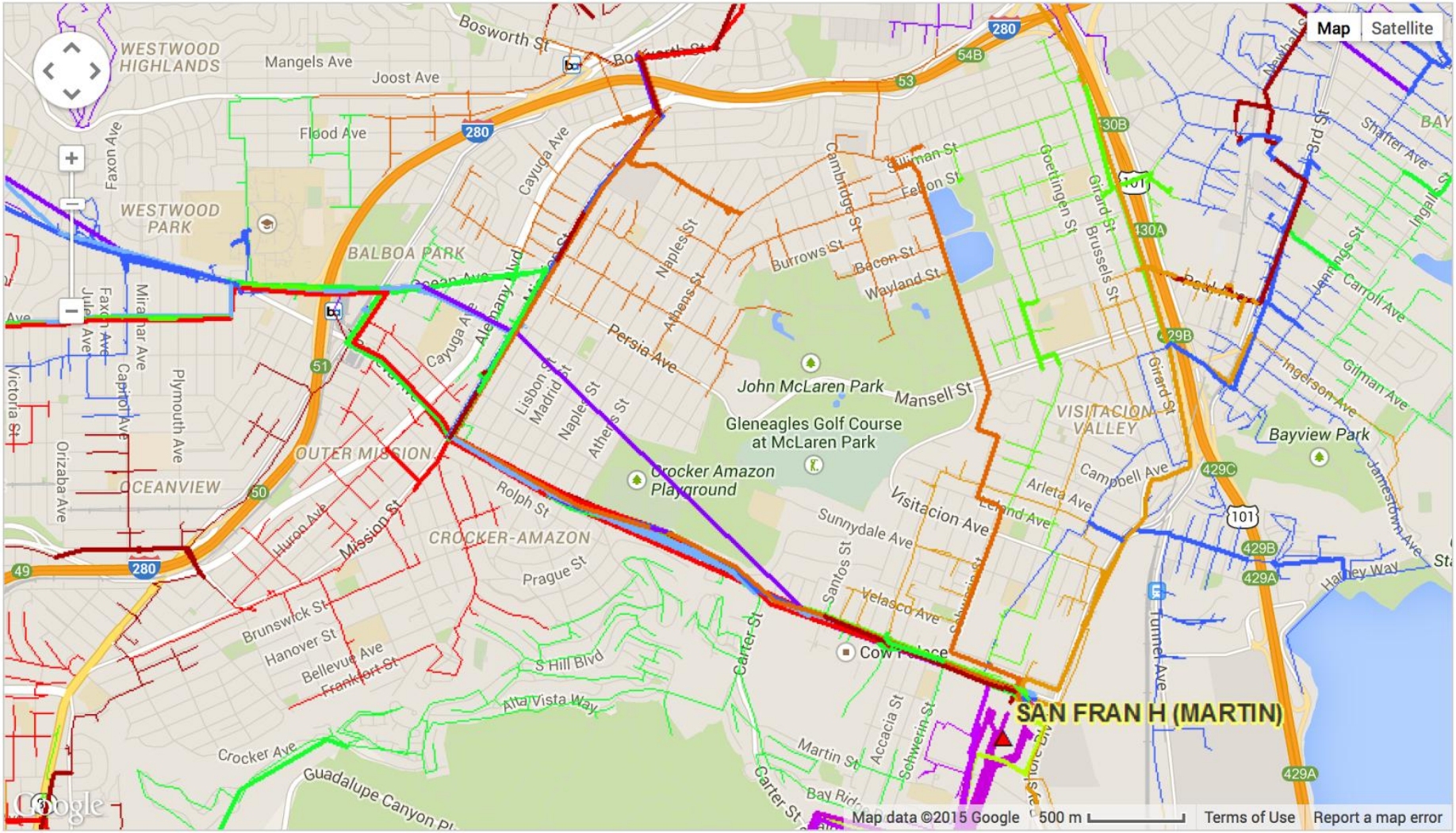
“Feeder level”



map width: 4.44 miles, map height: 2.54 miles

What do high penetration issues look like?

 | |

Why did this happen?

- Explosive, unplanned growth
- Solar “attached” to the grid, not integrated with it
- Significant grid reliability issues (e.g. voltage and frequency fluctuations)
- Aggregated effect of feeder level behavior on system level issues
- Processes, systems, diagnostics not equipped for the volume or the decentralized/local nature of grid issues
- Slowdown/complete stop of interconnections

High penetration DER – lessons learned

- **High distribution upgrade costs and delays in interconnection** will result from poor planning

- Good planning first starts with being able to see **feeder level circuits, not substation level** – DER driven issues are at the “local” level, but have system-wide impact

- Visibility into DER assets provides **significant value for modeling, planning, and generation scheduling** – locational value, easing interconnections, optimal DER mix

- **Advanced grid functions and optimal management** can further enhance system stability and increase feeder carrying capacity

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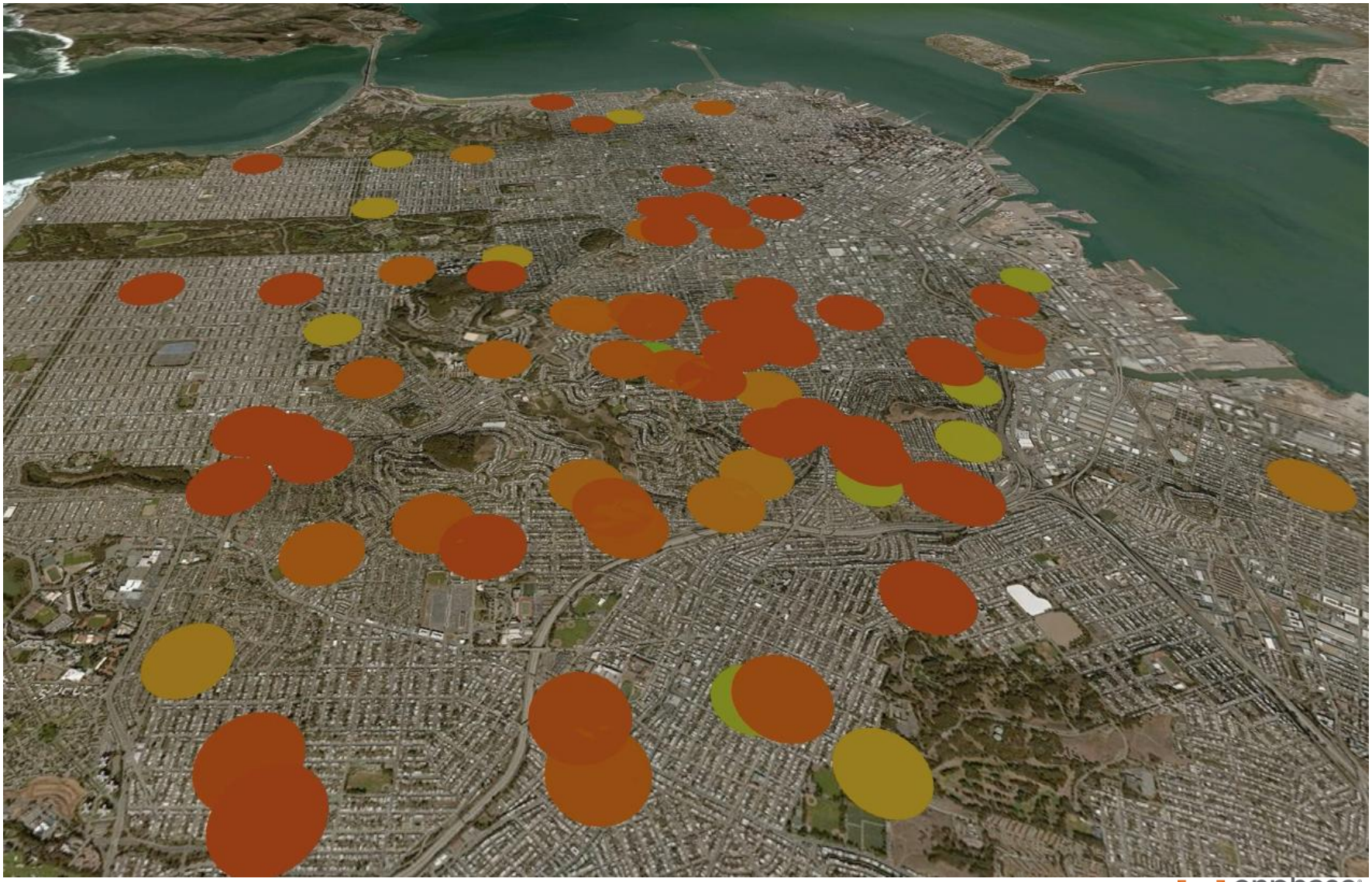
Does the data exist today?



Enphase network – visibility and management

- **Over 6M+ microinverters and 200,000+ systems WW**
- **700+GB/day; feeder power quality data every 5 mins.**
- **Ability to monitor and remotely upgrade systems for power quality management**
- **34,000+ systems in Hawaii**
- **75,000+ systems in California – 340MW! of solar**

Is there value? IA-Enphase Study

PRELIMINARY

- **Many different aspects of "value to the grid" – voltage fluctuations, power factor issues, capacity deferral, etc.**
- **Study focused on benefits from avoided costs, grid purchases, and power factor changes**
  - Significant other benefits exist, but not quantified in this study
- **Comparison of Net Benefits of Kvar and dynamic power factor control, with and without storage**
- **Analyzed feeder Subsection, with constraints**
  - PV sized to avoid reverse flow; Storage constrained to be less then PV
- **Approach: Identified optimal locations and size of PV**
  - Scenarios features adding storage, and added KVAR control to base PV optimal PV location base case.

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IA-Enphase Study: Benefits of dynamic KVAR control

PRELIMINARY

Analysis at the grid edge, with small scale storage competing with KVAR "injections", we find that the two are fairly comparable in terms of net savings and benefits *(for* avoided costs, grid purchases, and power factor changes)

- *Base Case:* *Optimally Located PV*
- *Optimally Placed PV with Storage Added:* *14% more savings*
- *Optimal PV with KVAR/ Power Factor Control:* *24% more savings*
- *Optimal PV, KVAR and Storage:* *26% more savings*

So, where do we go from here?

- **The Physics is known …** Ohm's law, Kirchoff's law, …
- **The high level goal is understood ...** Distribution level reliability, higher levels of DERs, …
- **The measured data is available …** across millions of DER devices, at a feeder/home level, …
- **The challenge is in pulling it all together …** at the local level, across thousands of feeders in California

What do we need to do?

- **Use granular, feeder level, actual data – it exists!**
- **Share feeder maps and data – a must for accurate analysis**
- **Model and validate based on measured data – instead of approximating and aggregating**
- **Develop standardized cost avoidance/benefit models leveraging granular data**
- **Undertake bold, “representative” pilots to accelerate DRP analysis and plans**

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